ORIGINAL
2/17/99

Cortical Control of Neural Prostheses

Quarterly Report #8

October 1, 1998 - December 31, 1998

(Contract NIH-NINDS-NO1-NS-6-2347)

Submitted to the Neural Prosthesis Program
National Institute of Neurological Disorders and Stroke
National Institutes of Health

By

Andrew Schwartz, Ph.D., Principal Investigator
Gary Yamaguchi, Ph.D., Co-Principal Investigator
Daryl Kipke, Ph.D.
Jiping He, Ph.D.
Jennie Si, Ph.D.
James Sweeney, Ph.D.
Robert Isaacs, M.D.

The Whitaker Center for Neuromechanical Control
Bioengineering Program
Arizona State University
Tempe, Arizona 85287-6006

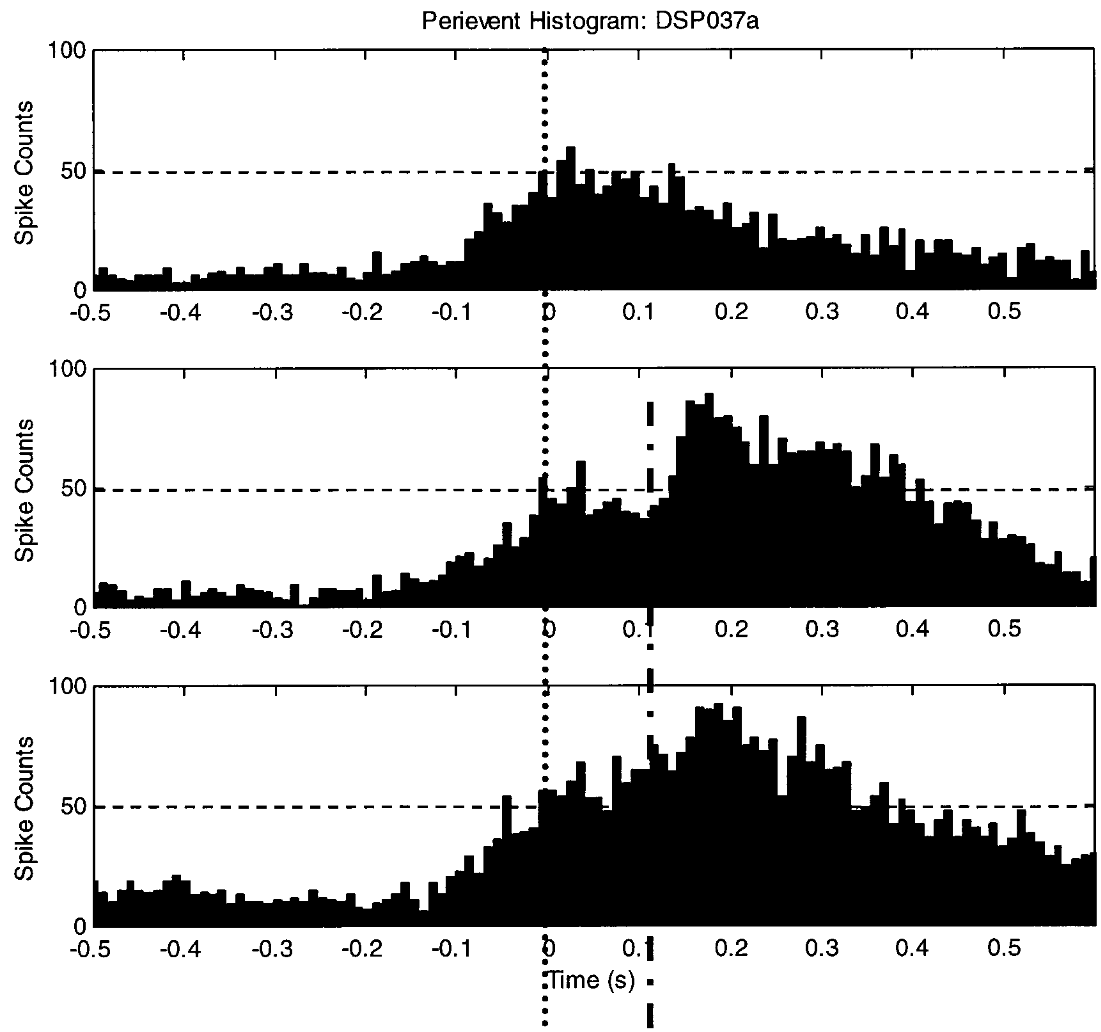
Work Preformed During the Reporting Period

In this reporting period, we continued to record spike data from our previously implanted monkeys. One new surgery was performed during this quarter. This animal was implanted with micro-wire arrays consisting of Teflon-coated stainless steel wires (50 microns in diameter) arranged in two linear arrays of eight wires each (spaced two hundred microns apart). The stainless steel electrode arrays were purchased from NB Labs. This surgery was performed in the second hemisphere of Monkey I.

The electrodes from the initial surgery on Monkey I became detached and all of the activity present, over thirty units, was lost. Our second surgery on Monkey I was unfortunately not as successful as the initial attempt. It received three NB electrode arrays after implantation of the antidromic depth electrodes. Antidromic responses were not found, and no significant cellular activity was recorded on the arrays. During the procedure, the pCO2 fluctuated from its optimal value of 35%. In future surgeries we will take more steps to maintain this optimum.

Excellent results have continued to be obtained from Monkey H. There continues to be activity on many channels, while discriminating approximately thirty units. There are multiple groups working on the analysis of this data. Our general thrust has been towards the use of neural networks and the use of the population vector approach to help derive a neural trajectory from this activity. A recent experiment looking into the cortical response to perturbation has shown intriguing responses from many of the units; further analysis of this should hopefully provide a more robust cortical control signal. (See Figure #1) The effect of synchrony has been examined and appears to provide additional

Adaptation in Cortical Response to Perturbation



Normal

(11/25, Run 4)

Naïve

(11/25, Run 5)

Adapted

(12/4, Run 2)

······· **Start of Movement** ⋮ perturbation information in addition to that found in isolated cells. Efforts are being directed at accessing this information in real-time.

The Plexon Corporation has developed a software client to access the spike data collection system on the Windows NT machine and make it available to the network. Spike data can be transmitted using TCP/IP to client computers on the network. We are also operating a UNIX version of the client on an SGI O2 to intercept the data and then pipe it to a raster plotting program. When finished, this program will plot out rasters corresponding to each of the eight targets for 16 simultaneously recorded units. This will update at the end of every trial. (See Figure #2)

The software client which can access the recorded cortical data in real-time from the Plexon Corporation server has been improved and efforts are being directed at upgrading our network to handle high-speed communication with this server. Although our program is still in its infancy, the firing rates of the units are acquired, and the information can be manipulated in the host computer or sent over the network to be altered into a control signal within another PC. Efforts are still being directed at improving our ability to derive 3-dimensional movement. Apart from the aforementioned ways, efforts to use temporal information and pattern recognition are being examined.

One of the objectives in our current study is to assess our ability to discriminate unit activity over a period of time. This is important for estimating how frequently the neural prostheses will need to be re-calibrated to achieve a certain performance, as well as what type of discrimination can be used and what type of signals are acceptable. It may be possible to use multiunit activity, signals that cannot be resolved to single units,

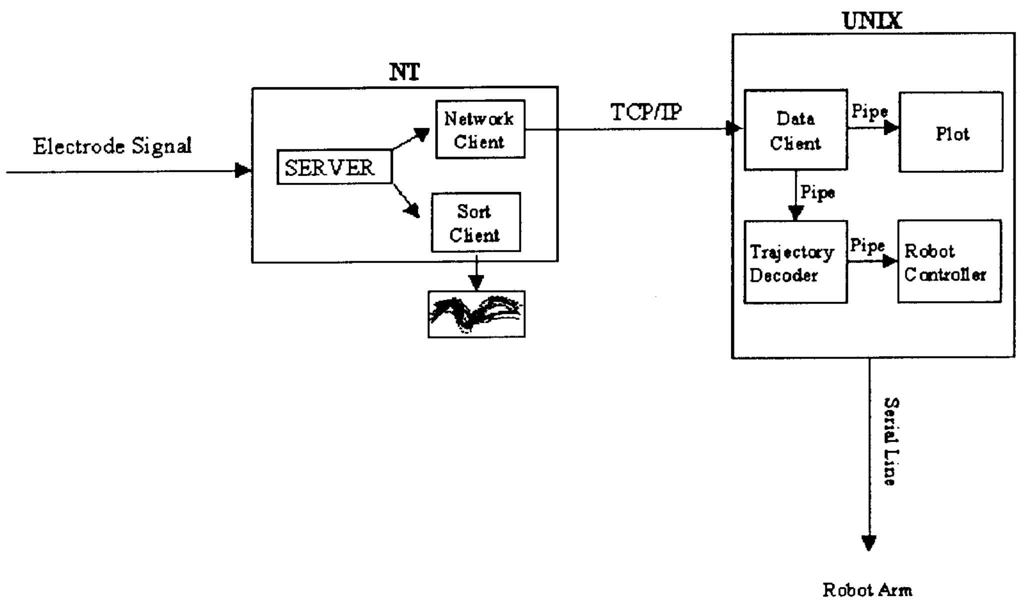


Figure 2. Real-time computer network design.

to extract arm trajectory information. This type of activity as well as the stability of isolated single units in time will be assessed for their usefulness as a control signal. We are beginning to answer these concerns to assess the longevity this technology.

Work anticipated for the Next Reporting Period

We plan by the next report to have implanted the second hemisphere of the second monkey discussed above, as well as obtain others for training and implantation. Our data analysis will continue primarily using the ways mentioned above in order to extract directional information from the cortical signal. Improvements to our real-time system are in the process of being added. We will continue looking into the stability question in order to establish criteria for using a prosthesis over the long haul. Finally, a prototype of a new electrode with an imbedded microdrive, displayed at the last Neural Prosthesis Program Annual Meeting, has been perfected and we hope to place it at the time of our next surgery.